ANNEX B

RIVERINE FLOODING
(INCLUDES FLASH FLOODS)

I. TYPE OF HAZARD

Riverine Flooding

II. DESCRIPTION OF HAZARD

Floods are the number one weather-related killer in the United States. Between 1990 and 2002, Missouri recorded more than 81 deaths attributed to flooding. A flood is partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur as a result of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event.

The areas adjacent to rivers and stream banks that carry excess floodwater during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat area adjoining a river or stream. The terms "base flood" and "100-year flood" refer to the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year, based on historical records. Floodplains are a vital part of a larger entity called a basin, which is defined as all the land drained by a river and its branches.

The land that forms the State of Missouri is contained within the Mississippi, Missouri, Arkansas, and White River Basins. The Mississippi River Basin drains the eastern part of the state, the Missouri River Basin drains most of the northern and central part of the state, the White River Basin drains the south-central part of the state, and the Arkansas River Basin drains the southwest part of the state. The Missouri River Basin drains over half the state. When the Missouri River joins the Mississippi River at St. Louis, it becomes part of the Mississippi River Basin, which is the largest basin, in terms of volume of water drained, on the North American continent.

In some cases, flooding may not be directly attributable to a river, stream, or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations–areas that are often not in a floodplain. This type of flooding, often referred to as sheet flooding, is becoming increasingly prevalent as development outstrips the ability of the drainage infrastructure to properly carry and disburse the water flow. Flooding also occurs due to combined storm and sanitary sewers that cannot handle the tremendous flow of water that often accompanies storm events. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns.

III. HISTORICAL STATISTICS

Missouri has a long and active history of extensive flooding over the past century. Scores of river communities, such as those along the Mississippi and Missouri Rivers, have become quite skilled and

experienced in flood-fighting efforts due to frequent instances of severe flooding in recent years. Flooding along Missouri's major rivers generally results in slow moving disasters. River crest levels are forecast several days in advance, allowing communities downstream sufficient time to take protective measures, such as sandbagging and evacuations. Nevertheless, these flood disasters extract a heavy toll in terms of human suffering and extensive losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

Ranking among the state's most notable flood disasters are the Missouri River flood of 1927, which spread destruction across 17 million acres, and the flood of 1951, which caused an estimated $400 million in damage. Record flooding also occurred in 1973 along the Mississippi River, where backwater inundated 474,000 acres at a loss of $40 million. The unseasonably heavy rainfall produced severe headwater flooding along many of the area's tributary streams, particularly in the St. John's Basin in Missouri and along the St. Francis and White Rivers in Arkansas. Of special historic interest is the December 1982 flood that spread dioxin-contaminated soil in the Times Beach area near St. Louis and led to a federal buyout of the entire town. In the fall of 1986, record flooding returned in Missouri, as well as in Michigan, Illinois, Kansas, and Oklahoma, with all these states declared federal disaster areas. Significant flooding next occurred in the state in the spring of 1990, particularly along the Missouri River in western, central, and portions of eastern Missouri. Record-level, repetitive flooding occurred from1993 through1995, and flash flooding ravaged several areas of the state in July and October 1998. In the springs of 1999 and 2000, flash flooding and severe storms again battered portions of the state.

Note: Counties designated as Disaster Areas in the 1993-1995, 1998, 1999, and 2000 floods are identified on maps in Section VII of this annex.

Floods of 1993-1995

The floods of 1993 through 1995 represent Missouri's worst repetitive flood events. Within this time frame were five Presidential Disaster Declarations, including four in just one 12-month period. This period extended from May 6, 1993, when the first declaration was issued by President Clinton, to April 17, 1994, when the fourth declaration was approved. Flooding in the spring of 1995 resulted in a fifth disaster declaration, issued on June 2, 1995. The ravages of these floods left a legacy of destruction, human suffering, and property damage of unprecedented terms in Missouri history. The fact that Missouri would need several years to recover from these repetitive flood disasters was undisputed. In 1993 alone, a total of 112 of Missouri's 114 counties were included in at least one or more of the declarations. Only Cedar County in southwest Missouri and Dunklin County in the southeast portion of the state were not included in any of the 1993 declarations.

Floods of 1998

Severe flash flooding in the summer and fall of 1998 took a heavy toll in terms of lives lost and extensive property damage in several areas of the state. In all, at least 17 people died as a result of the two flood events. Almost all of the casualties occurred when people attempted to drive their vehicles through rushing water, overturned their vehicle into floodwaters, or were trapped and swept off a flooded bridge. Both flood incidents ultimately resulted in Presidential Disaster Declarations to provide state and federal assistance in the declared counties.

Spring 1999 and 2000 Floods

On April 3, 1999, a heavy rainstorm in southeast Missouri caused severe flash flooding in Madison County, including the communities of Fredericktown and Marquand. One death (due to electrocution)

was attributed to that flood event when 7 to 10 inches of rain fell over a 2-hour period, causing the St. Francois River to crest at twice the height of flood stage. More than 400 homes were adversely affected, with nearly half receiving significant water damage within the living spaces. Seven businesses were damaged, and five were determined to be destroyed. On April 20, 1999, a Presidential Disaster Declaration for individual assistance (MO-DR 1270) was approved for Madison County and five additional counties (Andrew, Cole, Osage, Iron, and Macon) were later approved by FEMA as add-ons to that declaration as a result of subsequent tornadoes and storms. More than 30 Missouri counties were also designated as eligible for disaster relief for agricultural losses suffered from the April storms.

For two consecutive spring seasons, Missouri experienced devastating flash flooding that forced hundreds of people from their homes and caused millions of dollars in property damage to both homes and businesses. Although the flash flooding in both events was confined to few areas, the type of devastation was equal or greater than some of Missouri's worst river flooding events. On May 6 and 7, 2000, a slow-moving storm unleashed 15 inches of rain in Franklin and Jefferson Counties in less than 24 hours. The city of Union in Franklin County was among the hardest hit due to extreme flooding from Flat Creek. In all, 10 counties were included in Presidential Disaster Declaration MO DR 1328, issued on May 12, 2000. Three counties were declared eligible for public assistance and individual assistance, and seven others were declared for individual assistance.

Spring 2003

Flash flooding occurred on May 7th and 8th, and became a major flooding event across all of southern and central Missouri through the early afternoon of May 9th. In addition to the numerous road closures, bridges blocked by debris, evacuations of towns, campgrounds, parks, and moderate river flooding, many communities had their worst flooding in more than 10 years. In Howell County, the most significant damage occurred after the Warm Fork River washed out a portion of train track four miles southeast of West Plains, resulting in a train derailment. Four locomotives, each weighing 260,000 pounds, and 10 railroad cars were knocked off the tracks allowing diesel fuel to flow freely onto the ground. In addition to all of the flash flooding reports, river flooding became significant as all of the southern Missouri rivers rose above flood stage by the middle of May. Some of the rivers crested at levels equivalent to the 1993 flood event.

IV. MEASURE OF PROBABILITY AND SEVERITY

In terms of overall damage, Missouri's most severe single hazard is flooding. While the state averages some 26 tornadoes each year, damage is generally confined to small areas with few fatalities, if any. By contrast, flooding has resulted in more federal disaster declarations in Missouri than any other hazard in the past three decades. Prior to the Great Floods of 1993, Missouri received federal disaster declarations due to flooding in the spring of 1990, October 1986, June 1984, December 1982, August 1982 (Jackson County), April 1979, September 1977, July 1976, June 1974, and for extensive flooding in April 1973 and again in November 1973.

Missouri's vulnerability to flooding is greatly increased because it is subject to flooding from two principal sources: the Missouri River Basin and the upper Mississippi River Basin. Over one-third of the annual monetary losses due to flooding in the Missouri River Basin occur within the State of Missouri.

Flash flooding can occur virtually anywhere in the state experiencing an abundance of rainfall in a very short time span, as with the November 1993 flood disaster, and floods of 1998 and 1999. The backing up of tributary stream flows creates flooding problems along the Mississippi River, especially in the southern area of the state where the land tends to be very flat and at low elevations. Even though many flood

control projects have been implemented and directly aid in flood prevention, the state is still flood prone due to its geography and location.

The National Weather Service has three response levels for alerting the public as to the danger of floods, as described below:

Response Level	Activity
Flood Watch	Flash flooding or flooding is possible within the designated area.
Flood Warning	Flash flooding or flooding has been reported or is imminent. Necessary precautions should be taken at once.
Flood Advisory	Flooding of small streams, streets, and low-lying areas, such as railroad underpasses and urban storm drains, is occurring.

The threat of flooding is more likely in the spring, when late winter or spring rains, coupled with melting snow, fill river basins with too much water too quickly. Spring also represents the onset of severe weather in the form of thunderstorms, tornadoes, and heavy rains, which can generate flash flooding along these storm fronts. However, as demonstrated by the disaster declarations in December 1982 and the Great Summer Flood of 1993, severe flooding can occur in Missouri at any time of the year. Based on this information, the State rates the probability and severity of floods as high.

V. IMPACT OF THE HAZARD

The Federal Emergency Management Agency estimates that more than 216,000 households are within designated floodplains in Missouri. In addition, thousands of other Missouri residents are at risk to the dangers of flash flooding from rapidly rising creeks and tributaries, storm water runoff, and other similar flooding events. Nationwide, most flood deaths are from flash floods, and nearly half of these fatalities are auto related, according to the National Weather Service.

Of the 49 deaths recorded during the floods of 1993, 35 (71 percent) were from flash floods. In that same category, 20 deaths (77 percent) were related to motor vehicles caught in flash floods. Missouri's river flooding in 1993 claimed 14 lives, with 6 deaths (23 percent) attributed to motor vehicles. (See flood-related mortality charts and maps in Section VII.)

Missouri flood disasters have inflicted tremendous loss in terms of damage to personal property, businesses, infrastructure/public property, and agriculture. Total losses during the 1993 flood disasters were estimated at approximately $3 billion. In addition, agricultural losses were estimated at $1.8 billion, as 3.1 million acres of farmland were either damaged or went unplanted because of the 1993 rains. The Department of Agriculture estimated that 445,000 acres of Missouri River bottomland were destroyed by washouts and sand scouring. While levees designed to protect up to 50-year floods did their jobs, the amount of rain and up-river flooding took their toll. Of the 1,456 public and private levees in the state, approximately 840 were damaged.

Almost every Missourian was at some time affected by the 1993 floods through inundation of roadways, airports, and drinking water and sewage treatment facilities, and by loss of income. The Missouri Department of Labor and Industrial Relations reported that $6.2 million was disbursed for disaster unemployment assistance for people who lost work due to flooding from July 1993 through March 1994.

The floods of 1993-94 pointed out that too many Missourians were living in a floodplain. To rebuild in the floodplains, those whose homes sustained substantial damage (50 percent or more) were required to elevate the structures above the base flood level to protect from future flood damage. Under Missouri's Community Buyout Program, more than $30 million in federal money was committed to moving Missourians voluntarily out of the floodplains through the acquisition of primary residential properties. As a result of those actions, it is estimated that state taxpayers will save more than $200 million in future flood disaster claims.

VI. SYNOPSIS

Flood events are often accompanied by other types of severe weather, including tornadoes, lightning, and severe thunderstorm activity. These storms also present a danger to life and property, often resulting in many injuries, and in some cases, fatalities. Floodwaters themselves often interact with hazardous materials. This has prompted the evacuation of many citizens near such materials stored in large containers that could break loose or puncture as a result of flood activity. Such events occurred during the 1993 flood, when approximately 11,000 St. Louis residents residing near flood-threatened propane tanks were evacuated on July 30. Evacuations were also ordered on July 31, when bulk propane tanks were flooded by the River Des Peres in St. Louis County. Federal and state agencies retrieved more than 247 large storage tanks; 1,178 small tanks; 3,470 large drums (over 15 gallons); and 5,731 small drums that had been swept away by the floods.

Public health concerns that may result from flooding include the need for disease and injury surveillance, community sanitation to evaluate flood-affected food supplies, private water and sewage sanitation, and vector control (for mosquitoes and other entomology concerns).

VII. MAPS OR OTHER ATTACHMENTS

River Basin and Floodplain Maps are on file at the State Emergency Management Agency.

The following maps and tables depict additional Missouri flood information, generally from 1993 through 1999.

- Record High-Water Stages in Missouri During the Summer 1993 Flood: Table B-1
- Distribution of Levee Failures by Corps of Engineers District Number of Failed or Overtopped Levees, Summer 1993 Flood: Table B-2
- Causes of Death by Type of Flood, Summer/Fall 1993: Table B-3
- Spring 1993 Flood: Figure B-1
- Summer 1993 Flood: Figure B-2
- Fall 1993 Flood: Figure B-3
- Spring 1994 Flood: Figure B-4
- Spring 1995 Flood: Figure B-5
- July 1998 Flood: Figure B-6

- Fall 1998 Flood: Figure B-7
- Spring 1998 Flood and Storms: Figure B-8
- Spring 2000 Flood: Figure B-9
- Flood-Related Mortality, Missouri 1993: Figure B-10.

TABLE B-1

RECORD HIGH-WATER STAGES IN MISSOURI DURING THE SUMMER 1993 FLOOD (IN FEET)

River	1993 Level	Previous Record	Flood Stage
Mississippi River			
Hannibal	31.8	28.6	16
St. Louis	49.4	43.3	30
Cape Girardeau	48.0	45.6	32
Missouri River			
St. Joseph	32.7	26.8	
Kansas City	48.9	46.2	17
Jefferson City	38.6	34.2	32
Hermann	36.3	35.8	23
St. Charles	39.5	37.5	21

Source: U.S. Army Corps of Engineers (1993).

TABLE B-2

DISTRIBUTION OF LEVEE FAILURES BY CORPS OF ENGINEERS DISTRICT NUMBER OF FAILED OR OVERTOPPED LEVEES, SUMMER 1993 FLOOD

Corps of Engineers District	Federal Levees	Non-Federal Levees
St. Louis*	12 of 42	39 of 47
Kansas City**	6 of 48	810 of 810

Source: Natural Disaster Survey Report, "The Great Flood of '93."

Notes: The difference in the failure rates above is because most federal levees are designed to withstand a 100- to 500-year flood, while non-federal levees, predominantly protecting agricultural lands, are frequently designed for a flood with a return period of 50 years or less.

* Includes eastern Missouri and portions of Illinois.
** Includes northwestern, west-central, and portions of southwest Missouri, and areas in Kansas and Nebraska.

For information on specific river and stream gauge levels go to:

- Kansas City/Pleasant Hill: www.crh.noaa.gov/cgi-bin/ahps.cgi?eax.

- Springfield: www.crh.noaa.gov/cgi-bin/ahps.cgi?sgf
- St. Louis: www.crh.noaa.gov/cgi-bin/ahps.gfi?lsx.

TABLE B-3

SUMMER/FALL 1993
CAUSES OF DEATH BY TYPE OF FLOOD

	River Flood	Flash Flood	Total
Motor Vehicle	6 (23%)	20 (77%)	26 (53%)
Drowning	5 (25%)	14 (74%)	19 (39%)
Electrocution	1 (50%)	1 (50%)	2 (4%)
Cardiac	2 (100%)	0	2 (4%)
All Causes	14 (29%)	35 (71%)	49 (100%)

FIGURE B-1

SPRING 1993 FLOOD

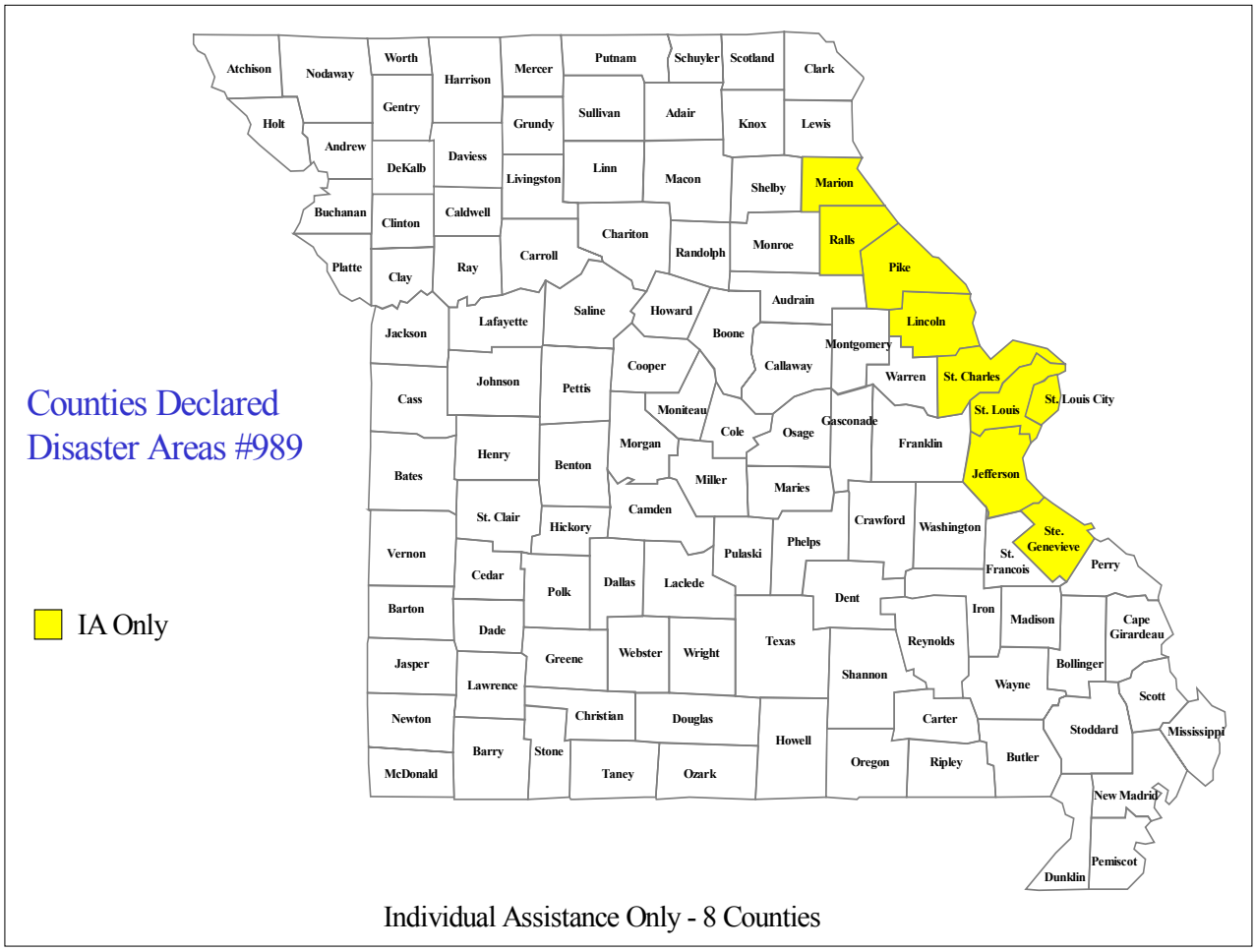


FIGURE B-2

SUMMER 1993 FLOOD

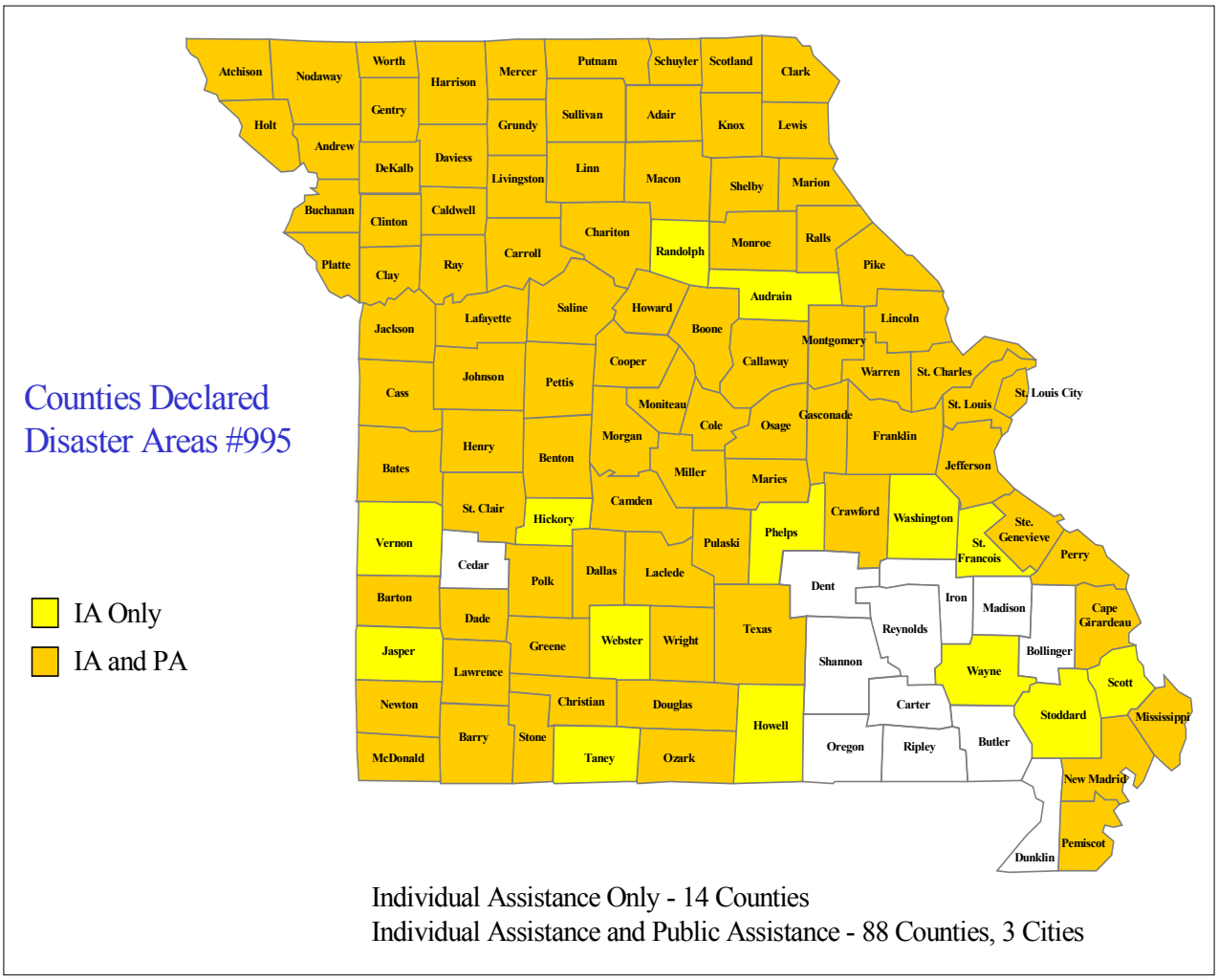


FIGURE B-3

FALL 1993 FLOOD

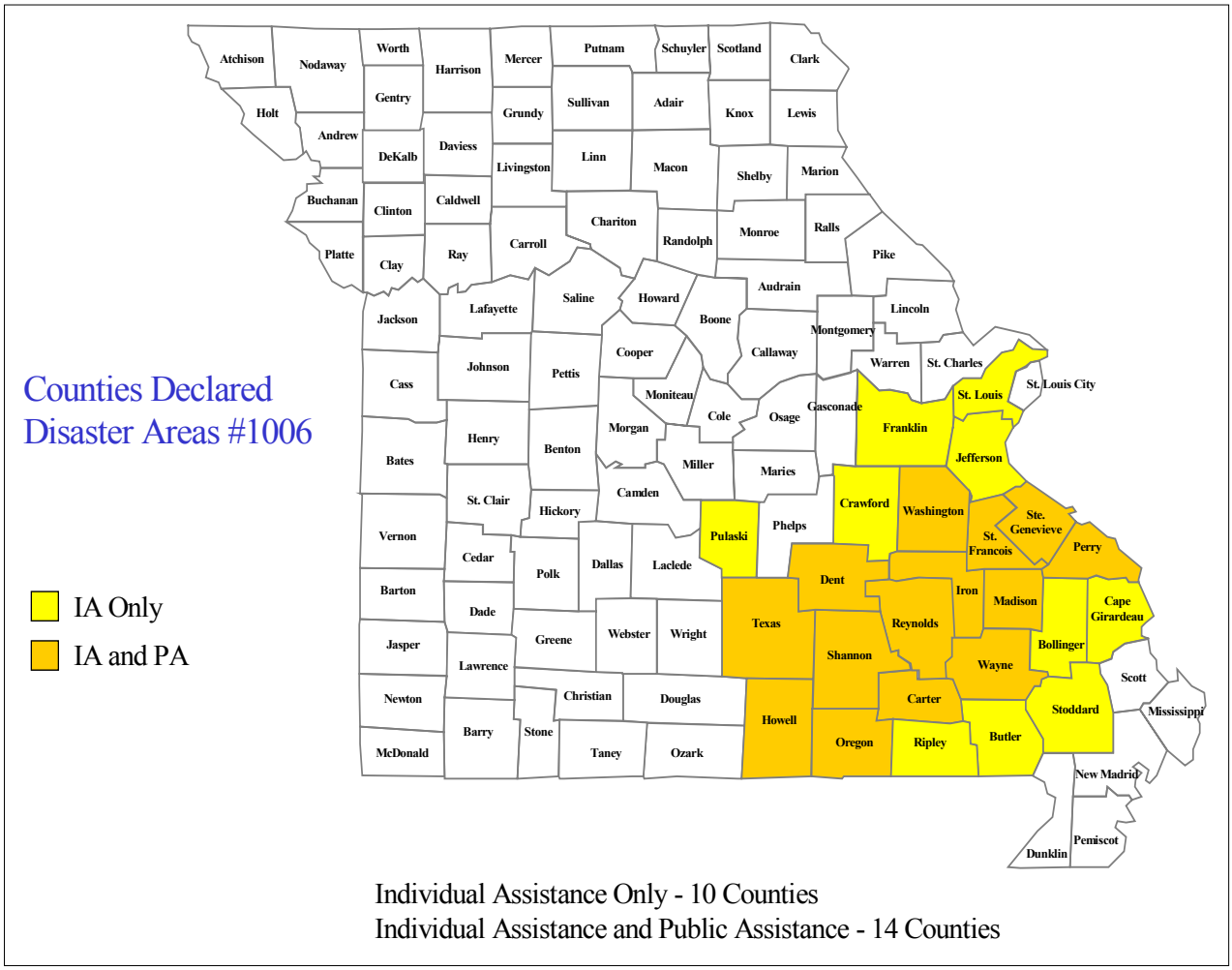


FIGURE B-4

SPRING 1994 FLOOD

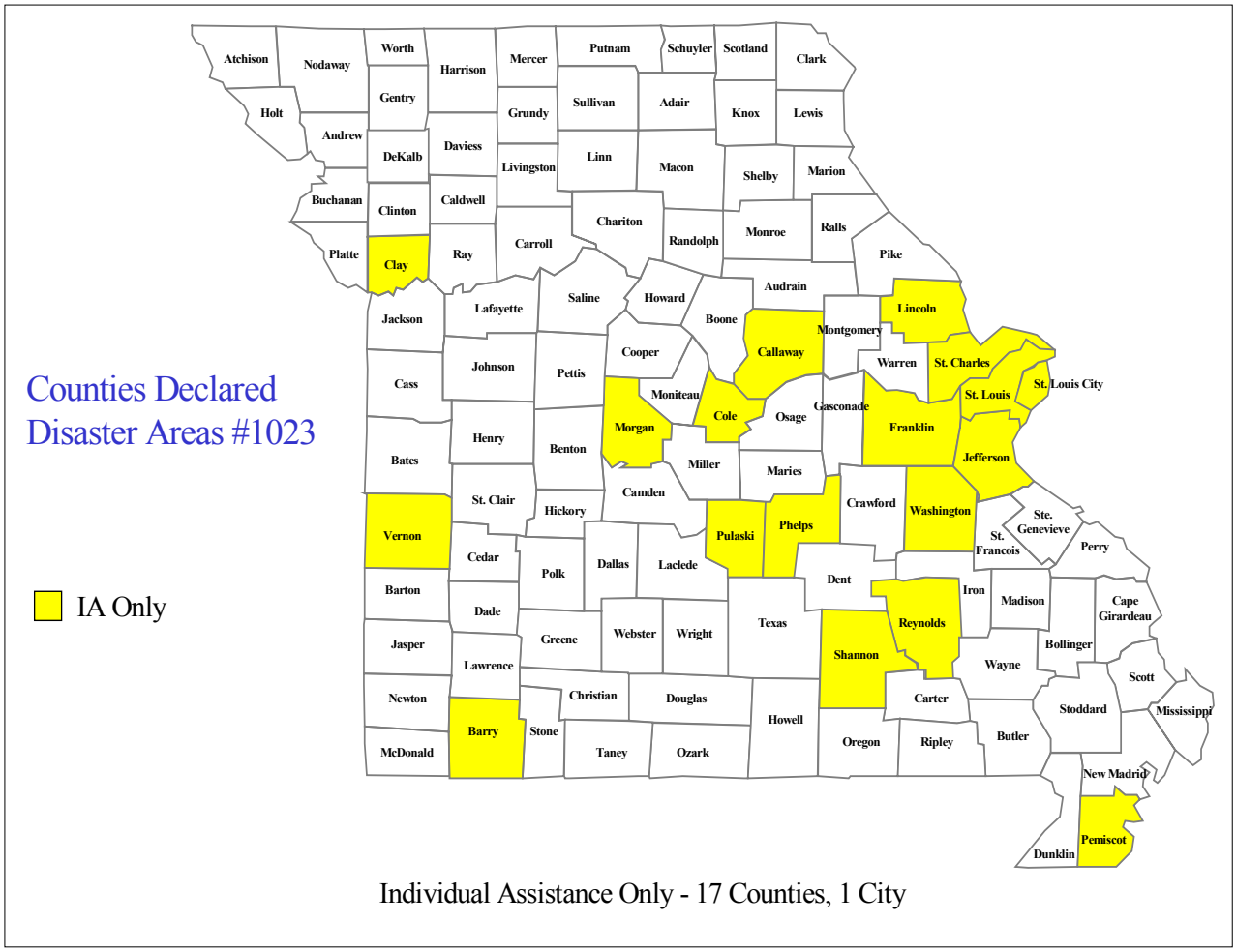


FIGURE B-5

SPRING 1995 FLOOD

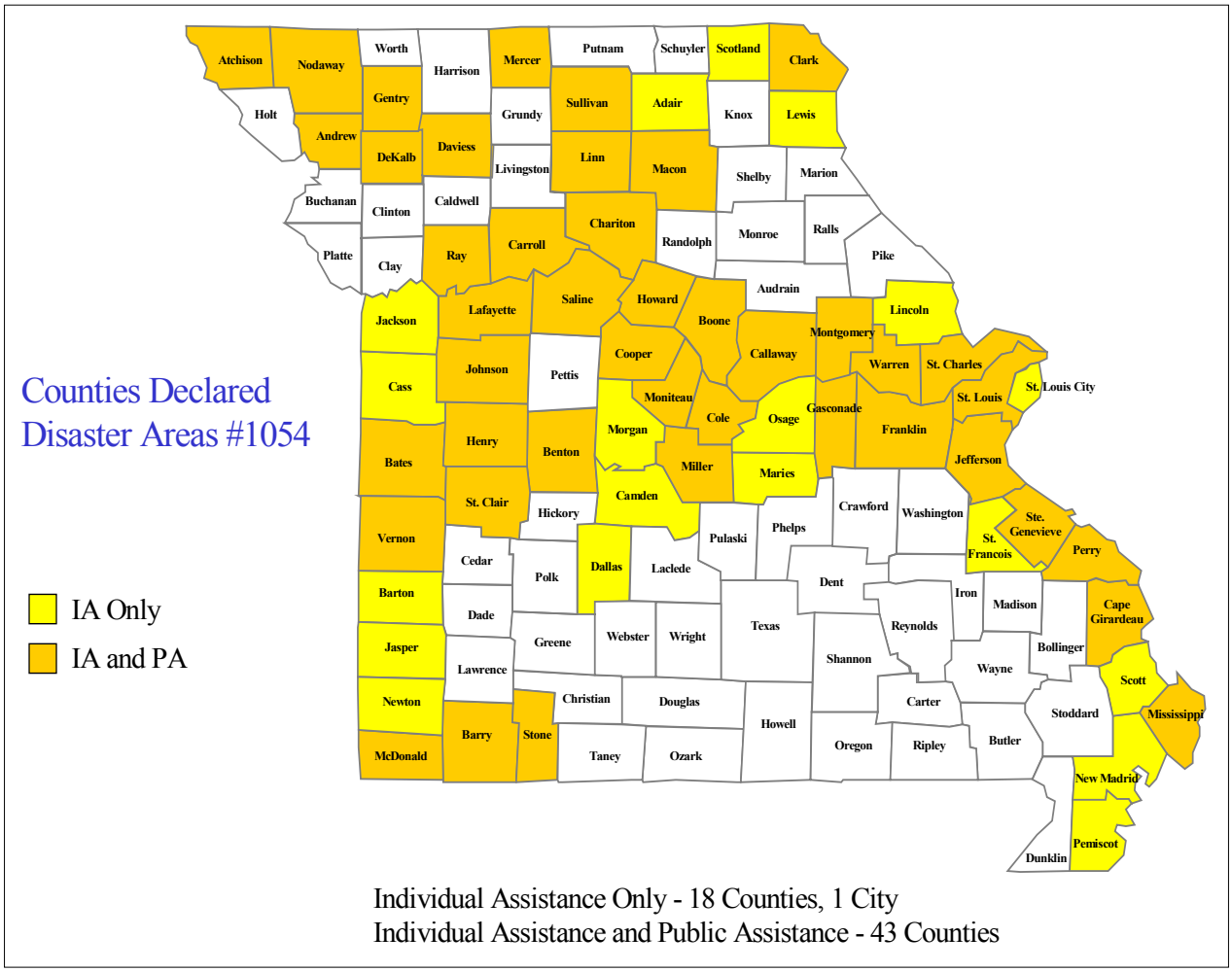


FIGURE B-6

JULY 1998 FLOOD

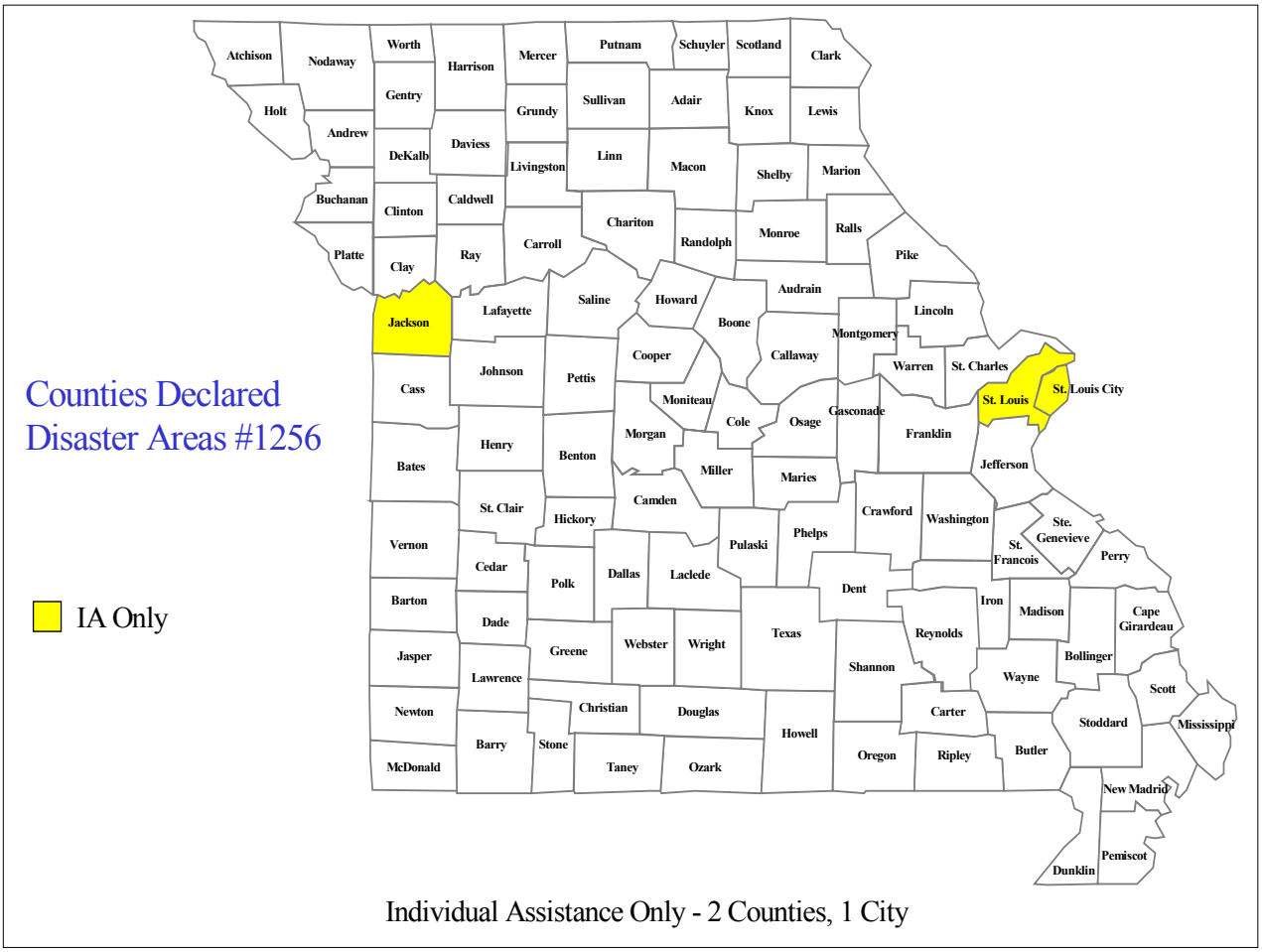


FIGURE B-7

FALL 1998 FLOOD

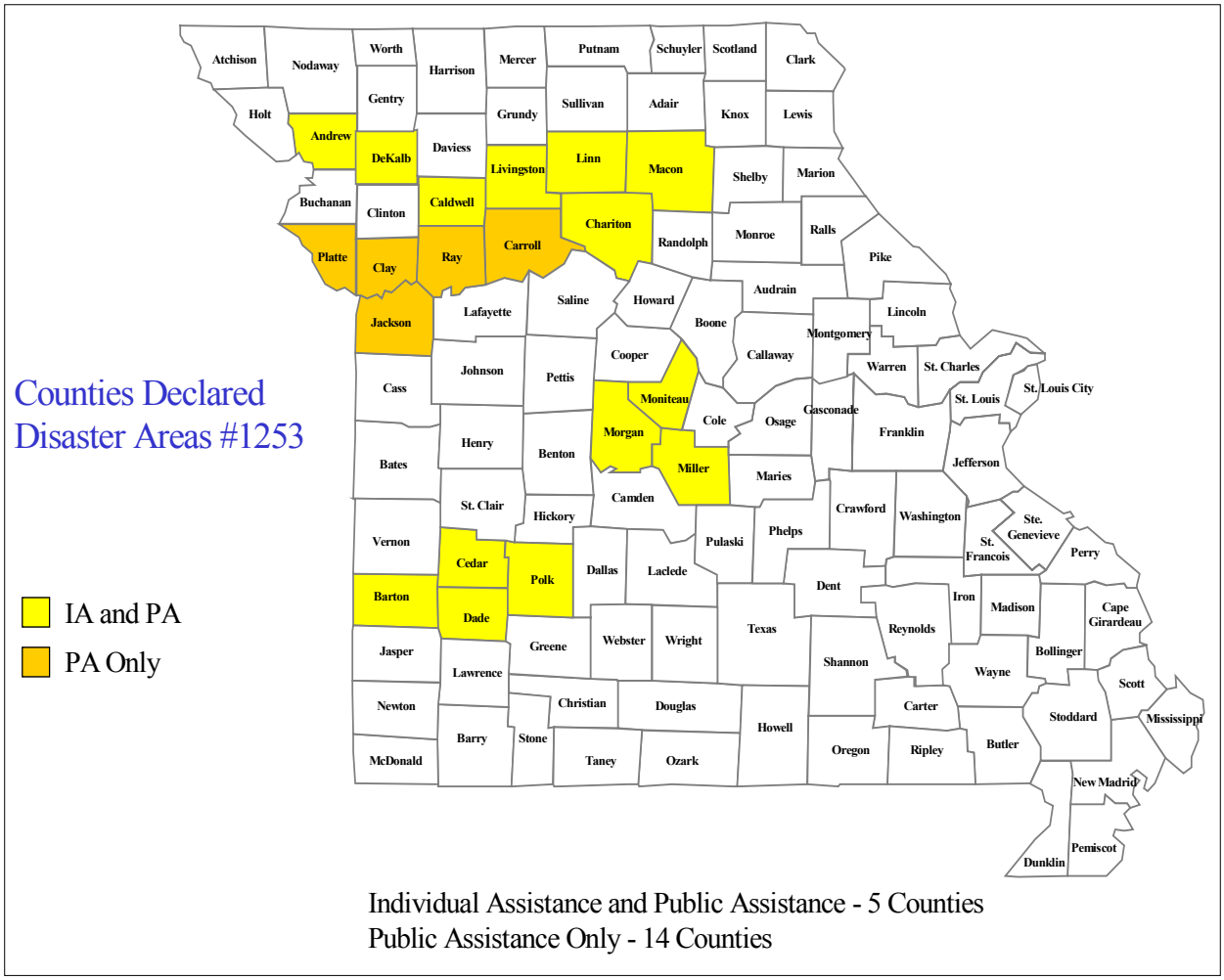


FIGURE B-8

SPRING 1998 FLOOD AND STORMS

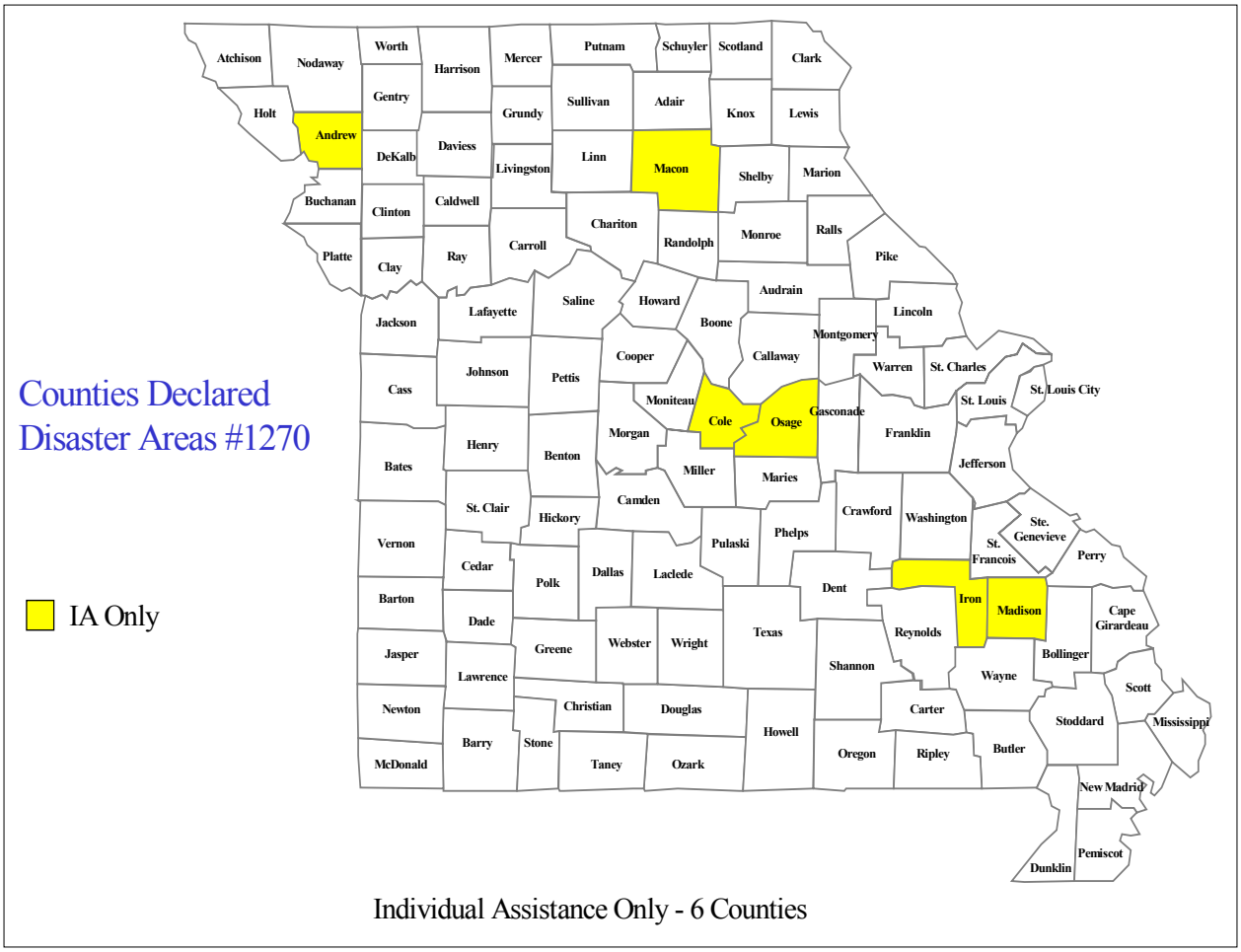


FIGURE B-9

SPRING 2000 FLOOD

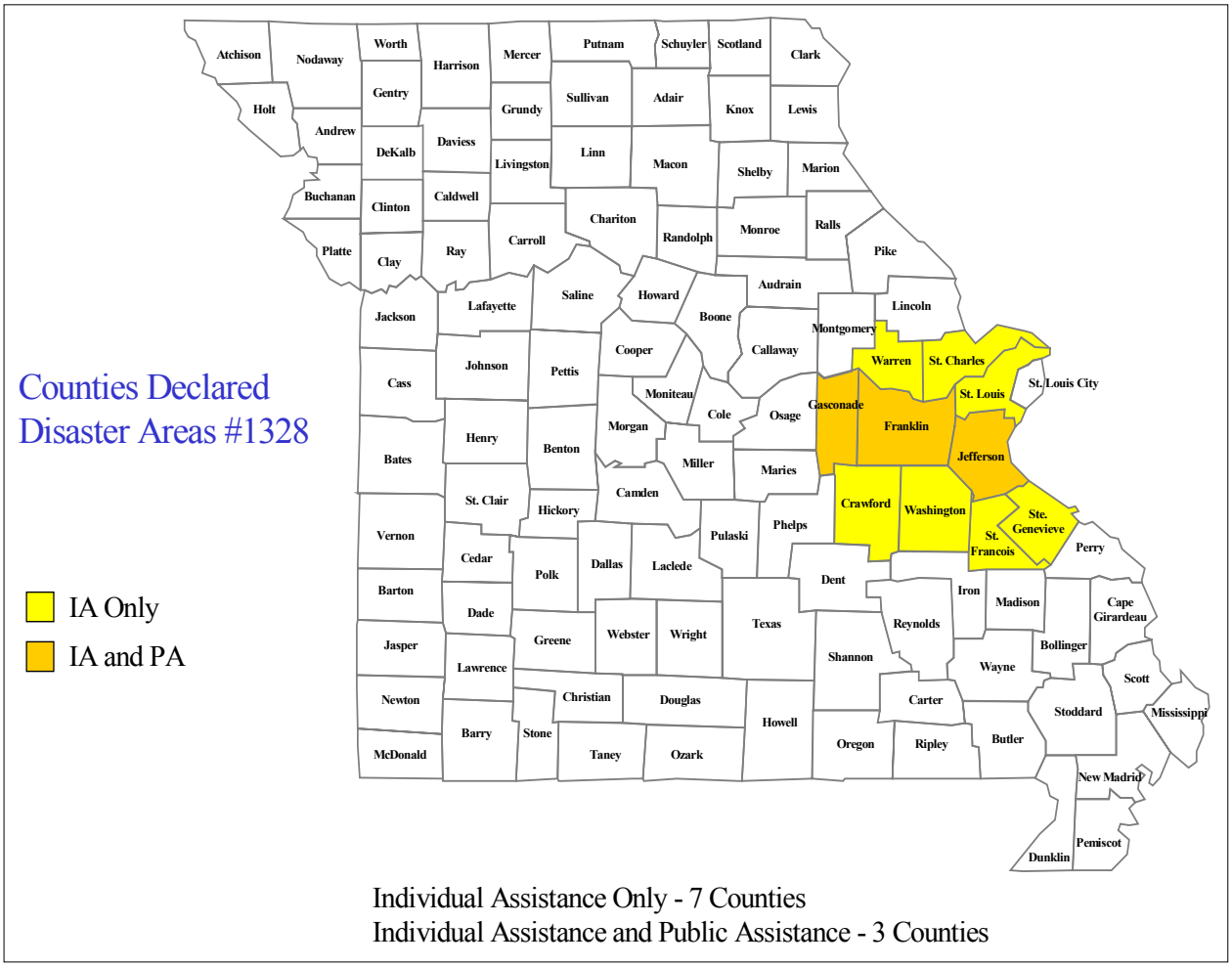
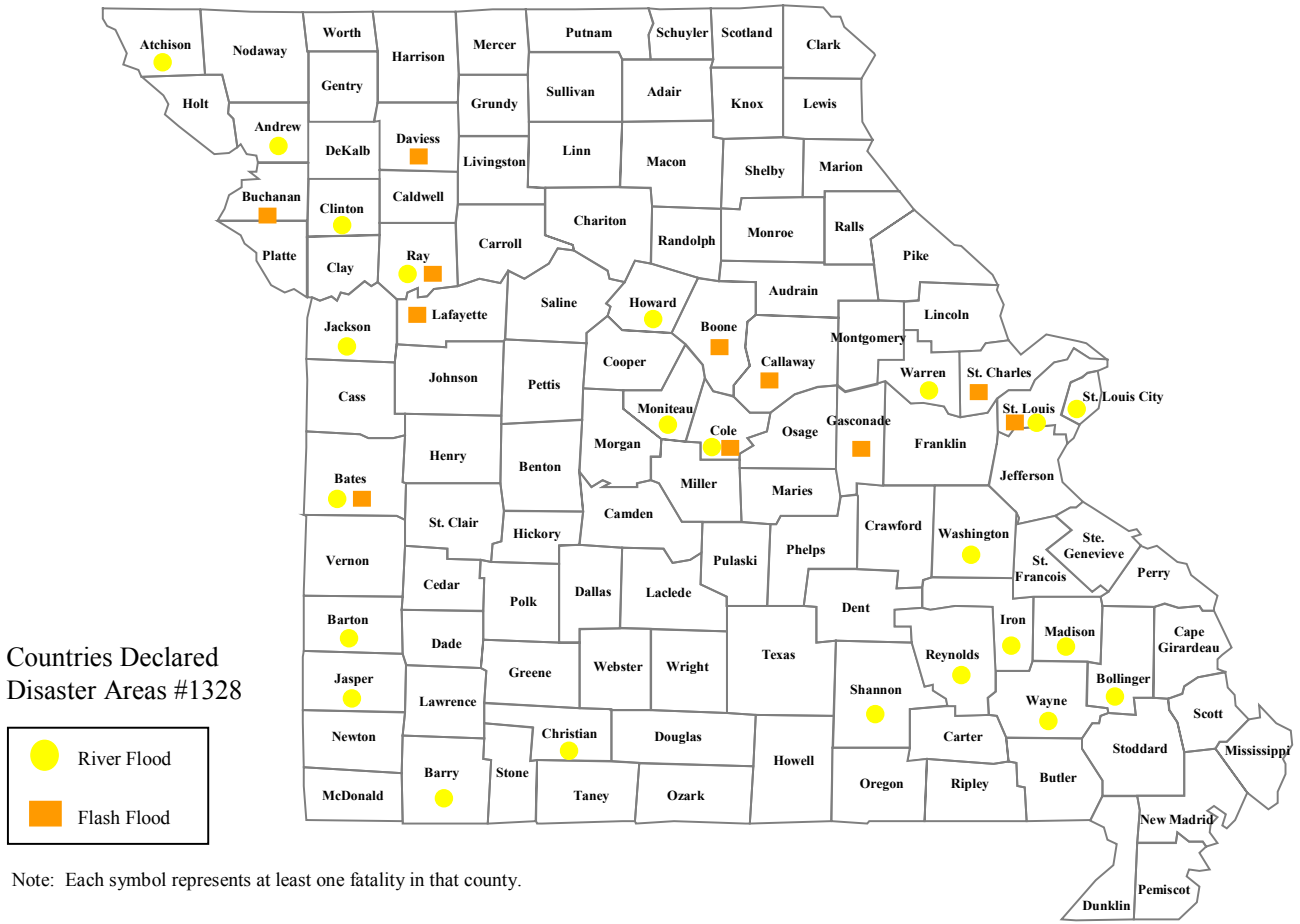


FIGURE B-10

FLOOD-RELATED MORTALITY
MISSOURI 1993



Note: Each symbol represents at least one fatality in that county.

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